Abstract

Sialon ceramics have been recently investigated as cutting tools due to their higher hardness than that of silicon nitride ceramics. Improvements in properties such as hardness, fracture toughness and chemical resistance through cBN reinforcement will make a cutting insert much more suitable for cutting and wear applications than that of pure sialon ceramic. This would result in a material with a significantly wider range of applications than that of the corresponding unreinforced sialon matrix.

This work investigated the fabrication of α-sialon ceramics as well as their corresponding cBN containing composites by spark plasma sintering. Fully dense (> 97 % theoretical density) sialon ceramics with a cBN content of up to 30 vol. % could be produced at sintering temperatures of 1575°C, the same temperature required for the pure matrix. An increase in the sintering temperature promotes the α-sialon transformation in the presence of yttrium as the stabilizing cation and thus the Vickers hardness is improved for pure sialon where an increase in the sintering temperature from 1575 to 1625°C results in an increase from 18.2 ± 0.4 to 19.6 ± 0.5 GPa.

It was observed that additions of cBN grains to the sialon matrix negatively affect the primary densification mechanisms present in liquid phase sintering, those being particle rearrangement and solution-precipitation processes. The phase transformation of some cBN grains in the cBN containing sialon composites were only observed at temperatures of 1600°C (partial/surface) and 1625 °C (high). Furthermore, through this work it was found that an optimum addition of cBN grains to the sialon matrix was 10 vol.%. Improvements in the Vickers hardness and fracture toughness through the addition of cBN grains were obtained at all sintering temperatures carried out through this scope of work. The improvements of the Vickers hardness for the sialon composites containing 10 vol. % cBN as compared to the pure sialon ceramic are given as follows for the relevant sintering temperatures: 1575 (18.2 → 20.9 GPa), 1600 (19.1 → 21.3 GPa) and 1625°C (19.7 → 20.7 GPa). cBN containing sialon composites sintered at 1575°C maintain hardness greater than that of pure sialon with increasing cBN content up to 30 vol. %

cBN, however at higher sintering temperatures considerable deterioration of the cBN grains was observed due to hexagonalization of the dispersed cBN grains; this resulted in composites with lower hardness than that of the pure sialon ceramic. The fracture toughness was seen to improve significantly with 10 vol. % cBN addition to the sialon matrix (3.6 → 5.2 MPa.$m^{0.5}$) when sintered at 1575°C; however further addition of cBN does not result in a further improvement of the fracture toughness unless hexagonalization of the cBN grains takes place which is promoted further with increasing sintering temperature. Composites containing 30 vol. % cBN and sintered at 1625°C exhibit fracture toughness as high as 7.8 MPa.$m^{0.5}$, as a result of the excessive hexagonalization of the cBN grains. Lastly through this work it was revealed that cBN containing sialon composites sintered with α-sialon as the matrix have superior mechanical properties to those cBN composites prepared through the use of β-sialon.